

Response

Page 2 of 9

Serial No.: 10/050,639

Confirmation No.: 6476

Filed: January 15, 2002

For: METHOD AND COMPOSITION FOR SELECTIVELY ETCHING AGAINST COBALT SILICIDE

combine reference teachings. Second, there must be a reasonable expectation of success.

Finally, the prior art references must teach or suggest all the claim limitations. *See* M.P.E.P. § 2143.

Claim 46 recites a method of selectively etching a portion of a metal nitride region against a cobalt silicide region using a solution including a mineral acid and a peroxide, wherein the solution etches the portion of the metal nitride region at an etch rate in a range of about 50 Å/minute to about 250 Å/minute.

The Examiner recognizes that Hayashi et al. does not describe a solution containing a mineral acid to etch TiN, e.g., a metal nitride described therein. However, the Examiner alleges Berti et al. teaches a method of etching metal nitride and cobalt using an etchant containing a mineral acid, such as phosphoric, acetic, and nitric acid, and further containing hydrogen peroxide.

The cited references do not teach or suggest all of the elements of claim 46, and therefore, claim 46 is not obvious in view thereof. As recognized by the Examiner, Hayashi et al. does not teach the etch rates for selectively etching metal nitride against cobalt silicide as described in claim 46. Hayashi et al. is silent as to etch rates of various disclosed solutions.

Berti et al. teaches some etch rates based on calculations made with respect to titanium nitride thickness and cobalt thickness in view of given etching times. However, in the Examiner's Response to Arguments, such calculations are alleged by the Examiner to not provide adequate etch rate information. As such, it would appear that per the Examiner's comments, Berti et al. also does not provide etch rate information (although, Applicants believe that at least a general understanding of such etch rates can be discerned from the given information in Berti et al.). As such, neither Hayashi et al. nor Berti et al. provide etch rate information, at least according to the Examiner.

The Examiner further alleges that etch rates of metal nitride depend on chemical concentrations which are determined through test runs in order to achieve optimum concentrations to etch metal nitride. However, as determined by the Examiner, etch rates are not shown by references and "[s]ilence in a reference is hardly a proper substitute for an adequate

Response

Serial No.: 10/050,639

Confirmation No.: 6476

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For: METHOD AND COMPOSITION FOR SELECTIVELY ETCHING AGAINST COBALT SILICIDE

Page 3 of 9

disclosure of facts from which a conclusion of obviousness may justifiably follow." *In re Burt and Walter*, 148 U.S.P.Q. 548, 553 (C.C.P.A. 1966).

Further, Applicants continue to submit that the etch rates disclosed in Berti et al. cannot be ignored, and that the cited references must be viewed in their entirety. As such, in view of the etch rates described in Berti et al., and there inapplicability to Hayashi et al., claim 46 is not *prima facie* obvious in view of the cited references.

Claim 46 as stated above includes a solution that etches the portion of the metal nitride region at an etch rate in a range of about 50 Å/minute to about 250 Å/minute. As stated above, Hayashi et al. is silent regarding etch rates. The addition of Berti et al. does nothing to correct this deficiency already present in Hayashi et al. In fact, the etch rates of Berti et al. teach away from using higher etch rates, especially considering the Examiner's suggestion that the solutions can be diluted with deionized water.

As previously argued in response to a prior office action, Berti et al. teaches removing unwanted cobalt and titanium nitride by immersing the wafer for 30 minutes in a mixture of phosphoric, acetic, and nitric acids and hydrogen peroxide. The thickness of the titanium nitride layer prior to silicidation is 50 to 150 Å. See Berti et al., column 3, lines 24-26. Therefore, the etch rate of the titanium nitride as taught by Berti et al. is 1.66 Å/minute for a 50 Å layer to 5 Å/minute for a 150 Å layer. Claim 46, on the other hand, recites etch rates of about 50 Å/minute to about 150 Å/minute for the metal nitride region, which are much faster rates than those taught by Berti et al.

Comments on Examiner's Response to Arguments

The Examiner, in response thereto, indicates that the Applicant's argument about the etch rates described in Berti et al. for TiN are flawed in that Berti et al. discloses an etching time of 30 minutes for both cobalt and TiN. However, even if the entire described thickness of TiN and Co were consider (i.e., 450 Å), the etch rate for both thicknesses would still be only 15 Å/minute. However, it is indicated that at least a portion (and usually a substantial portion to reduce the amount of unreacted Co to be removed) of the Co is consumed during

Response

Page 4 of 9

Serial No.: 10/050,639

Confirmation No.: 6476

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For: METHOD AND COMPOSITION FOR SELECTIVELY ETCHING AGAINST COBALT SILICIDE

the silicidation process. Therefore, the 15 Å/minute rate is clearly lower. As such, Applicant continues to argue that Berti et al. does not show the etch rates described in the pending claims and actually shows rates that are much lower than the claimed rates for the etching composition used according to the present invention.

For at least the above reasons, claim 46 is not obvious in view of the cited references. Further, claims 51-59 are not *prima facie* obvious in view of the cited references for the same reasons by way of their dependency on claim 46.

Further, claims 51-59 recite additional elements that further support patentability when combined with claim 46. For example, claim 53 recites that the solution includes a ratio in a range of about 1:1:35 (mineral acid:peroxide:deionized water) to about 1:1:5 (mineral acid:peroxide:deionized water). As admitted by the Examiner, neither Hayashi et al. nor Berti et al. teaches solutions that include deionized water. However, the Examiner alleges that it would have been obvious to one of skill in the art to dilute the solution with an appropriate amount of deionized water, creating a concentration of mineral acid and peroxide that would optimize the removing process of metal nitride and cobalt against the cobalt silicide. Applicants traverse this allegation and submit that Berti et al. teaches away from this alleged motivation.

Comments on Examiner's Response to Arguments

The Examiner continues to assert that (as generally summarized by the Applicant) using deionized water to prepare any solution would be obvious and that routine experimentation would provide the etching rate claimed. However, as stated above, Berti et al. teaches an etch rate for titanium nitride that is much lower than the claimed etch rate. Diluting the solution taught by Berti et al. with deionized water, as is suggested by the Examiner, would cause the etch rate for titanium nitride to decrease, thereby becoming even further slower than the etch rate recited. Therefore, one skilled in the art would not be motivated to dilute the solution taught by Berti et al. to provide the present invention. The Examiner continues to fail to address such lack of motivation.

Response

Page 5 of 9

Serial No.: 10/050,639

Confirmation No.: 6476

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For: METHOD AND COMPOSITION FOR SELECTIVELY ETCHING AGAINST COBALT SILICIDE

For at least the above reasons, Applicants submit that claims 46 and 51-59 are not *prima facie* obvious in view of the cited references. Reconsideration and withdrawal of this rejection are, therefore, respectfully requested.

II. Whether claims 60-67 are patentable under 35 U.S.C. § 103(a) over Wei et al. in view of Berti et al.

The Examiner rejected claims 60-67 under 35 U.S.C. § 103(a) as being unpatentable over Wei et al. (U.S. Patent No. 5,047,367) in view of Berti et al. Applicants traverse this rejection and submit that the arguments previously presented overcome the rejection. Such previously presented arguments are incorporated by reference herein. Further, the following information is provided to support the conclusion that such claims are not obvious in view of Wei et al. and Berti et al.

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art references must teach or suggest all the claim limitations. See M.P.E.P. § 2143.

Claims 60-67 are clearly not *prima facie* obvious as there is no suggestion or motivation to combine the teachings of such references. In fact, Wei et al. actually teaches away from being combined with Berti et al. It is improper to combine references where the references teach away from their combination. See *In re Grasselli*, 218 U.S.P.Q. 769, 779 (Fed. Cir. 1983).

For example, Wei et al. teaches forming a titanium layer on a silicon substrate. See Wei et al., column 3, lines 16-17. A conformal layer of cobalt is then formed on the titanium layer. *Id.* at column 3, lines 18-20. After depositing the titanium and cobalt, the substrate is annealed in a nitrogen or ammonia ambient, causing the titanium to diffuse upward through the cobalt to the surface, while the cobalt diffuses downward to the silicon surface where it reacts to form

Response

Page 6 of 9

Serial No.: 10/050,639

Confirmation No.: 6476

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For: METHOD AND COMPOSITION FOR SELECTIVELY ETCHING AGAINST COBALT SILICIDE

cobalt silicide. *Id.* at column 3, lines 21-29. At the surface, the titanium reacts with the nitrogen atmosphere to form titanium nitride. *Id.* at column 3, lines 34-36.

After the first anneal, Wei et al. teaches that an intermediate structure is formed (*see* FIG. 4) in those regions where the titanium layer and the cobalt layer overlie silicon (e.g., regions 23, 24, and 21 of FIG. 7). Following the first anneal, the intermediate structure (FIG. 7) is etched to remove the unreacted cobalt and the unreacted titanium. *Id.* at column 7, lines 57-58. The cobalt is etched using a mixture of nitric acid and water. The titanium is etched using a mixture of hydrogen peroxide, ammonium hydroxide, and water. *Id.* at column 7, lines 58-65. Wei et al. teaches that these etches are selective in that they remove all unreacted metal but do not etch the intermediate silicide/nitride structures. *Id.* at column 8, lines 1-4. In other words, the cobalt and titanium etches taught by Wei et al. do not etch the titanium nitride being formed at the surface of the structure.

Berti et al., on the other hand, teaches etching cobalt and titanium nitride at the same time using the same solution. One skilled in the art would not be motivated to combine the teachings of Wei et al. with Berti et al. because Wei et al. teaches etching cobalt and titanium without etching titanium nitride, while Berti et al. teaches etching both cobalt and titanium nitride simultaneously.

The Examiner continues to fail to address Applicant's argument that Wei et al. teaches away from being combined with Berti et al. As stated above, Wei et al. teaches that the intermediate titanium nitride structure is not etched using either the mixture of nitric acid and water or the mixture of hydrogen peroxide, ammonium hydroxide, and water. *See* Wei et al., column 8, lines 1-4. Berti et al. teaches etching cobalt and titanium nitride at the same time using a mixture of phosphoric, acetic, and nitric acids and hydrogen peroxide. Applicants respectfully ask the Examiner why one skilled in the art would use the mixture of Berti et al. that etches titanium nitride in the process of Wei et al., when Wei et al. specifically states that titanium nitride is not etched.

For the above reasons, claim 60 is not obvious in view of the cited references. Further, claims 61-67, which depend, either directly or ultimately, from claim 60 and therefore include all

Response

Serial No.: 10/050,639

Confirmation No.: 6476

Filed: January 15, 2002

For: METHOD AND COMPOSITION FOR SELECTIVELY ETCHING AGAINST COBALT SILICIDE

Page 7 of 9

the limitations thereof, are not *prima facie* obvious in view of the cited references for the same reasons as presented above for claim 60. In addition, claims 61-67 each recite additional elements that further support patentability when combined with claim 60.

For example, claim 62 recites that the mineral acid includes HCl. The combination of Wei et al. and Berti et al., on the other hand, does not teach a solution that includes HCl. Further, there is no suggestion or motivation in either reference that would lead one skilled in the art to add HCl to the solutions taught by either reference.

Further, for example, claim 64 teaches that the solution includes a ratio in a range of about 1:1:300 (mineral acid:peroxide:deionized water) to about 1:1:70 (mineral acid:peroxide:deionized water). The combination of Wei et al. and Berti et al., on the other hand, does not teach or suggest such ratios. For example, as stated above, Wei et al. teaches etching cobalt using a mixture of nitric acid and water where the mixture is a ratio of approximately 1:1. In other words, Wei et al. does not teach a solution of mineral acid, peroxide, and deionized water in a ratio of 1:1:300 to about 1:1:70 as recited by claim 64.

The addition of Berti et al. does nothing to correct this deficiency already present in Wei et al. For example, Berti et al. teaches etching both cobalt and titanium nitride using a mixture of phosphoric, acetic, and nitric acids and hydrogen peroxide. Berti et al. does not teach any ratios for the etching mixture. One skilled in the art would not be motivated to combine the teachings of Wei et al. and Berti et al. to produce the present invention because the two references teach completely different mixtures, and the references, either alone or in combination, do not teach the solutions and/or ratios recited by claim 64.

In addition, claim 66 recites that the cobalt region is selectively etched against the metal nitride region at an etch rate in a range of about 50 Å/minute to about 500 Å/minute. In contrast to claim 66, Wei et al. does not teach any etch rates. Berti et al. discloses an etching time of 30 minutes for both cobalt and TiN. However, even if the entire described thickness of TiN and Co were considered (i.e., 450 Å), the etch rate for both thicknesses would still be only 15 Å/minute. Following silicidation, the unconsumed cobalt is removed. However, it is indicated that at least a portion (and usually a substantial portion to reduce the amount of unreacted Co to be removed)

Response

Page 8 of 9

Serial No.: 10/050,639

Confirmation No.: 6476

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For: METHOD AND COMPOSITION FOR SELECTIVELY ETCHING AGAINST COBALT SILICIDE

of the Co is consumed during the silicidation process. Therefore, the 15 Å/minute rate is clearly lower. In other words, the etch rates taught by Berti et al. are much slower than the etch rates recited in claim 66. Because this combination of references does not teach all the elements of claim 66, such claim is not *prima facie* obvious in light thereof.

It does not appear that the arguments presented above with respect to the dependent claims have been addressed by the Examiner.

For at least the above reasons, Applicants submit that claims 60-67 are not *prima facie* obvious in view of the cited references. Reconsideration and withdrawal of this rejection are, therefore, respectfully requested.

Allowable Subject Matter

Applicant acknowledges the allowance of claims 68-88.

Response

Page 9 of 9

Serial No.: 10/050,639

Confirmation No.: 6476

Filed: January 15, 2002

For: METHOD AND COMPOSITION FOR SELECTIVELY ETCHING AGAINST COBALT SILICIDE

Summary

It is respectfully submitted that the pending claims are in condition for allowance and notification to that effect is respectfully requested. The Examiner is invited to contact Applicants' Representatives, at the below-listed telephone number, if it is believed that prosecution of this application may be assisted thereby.

Respectfully submitted for

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CERTIFICATE UNDER 37 CFR §1.8:

The undersigned hereby certifies that this paper is being transmitted by facsimile in accordance with 37 CFR §1.6(d) to the Patent and Trademark Office, addressed to Assistant Commissioner for Patents, Washington, D.C. 20231, on this 14th day of April, 2003, at 1:45pm (Central Time).

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